GEO.KS38 Energy Security Case Study: Whitelee Windfarm and Sustainable Energy Use

Total Marks

AQA 8035 · Calculators not allowed · about 40 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 State the location of Whitelee Windfarm in the UK, giving the nearest major city and the broader region.

(Total for Question 1 is 2 marks)

---

2 State the installed electrical capacity of Whitelee Windfarm and explain what is meant by 'installed capacity'.

(Total for Question 2 is 2 marks)

---

3 Give ONE advantage of Whitelee Windfarm for local employment in the area around Glasgow.

(Total for Question 3 is 1 mark)

---

4 Give ONE disadvantage of Whitelee Windfarm relating to its environmental or visual impact on Eaglesham Moor.

(Total for Question 4 is 1 mark)

5 Table 1 shows Whitelee Windfarm's annual electricity generation in GWh for five recent years. Use the table to answer the following.

Table 1, Whitelee annual generation (GWh): 2018: 980; 2019: 1,050; 2020: 920; 2021: 1,180; 2022: 1,100.

(a) State the year with the highest recorded generation and the year with the lowest recorded generation in Table 1. **(1)**

(b) Calculate the difference in generation between the highest and lowest years in Table 1. Give your answer in GWh. **(2)**

.....

(c) Describe the overall pattern of generation shown by Table 1 across these five years. **(1)**

(Total for Question 5 is 4 marks)

---

6 Using the 2022 generation from Table 1 and an installed capacity of 539 MW for Whitelee, calculate the capacity factor for 2022. Show your working and give your answer to one decimal place. Use hours per year = 8,760 hours. The formula is: capacity factor = (annual generation in MWh) / (installed capacity in MW x hours per year) x 100.

(Total for Question 6 is 2 marks)

---

7 Give ONE way in which Whitelee Windfarm contributes to sustainable energy use in Scotland or the UK.

(Total for Question 7 is 1 mark)

---

8 Suggest ONE reason why Whitelee's electricity output is described as intermittent and explain how this affects energy reliability.

(Total for Question 8 is 1 mark)

9 Give ONE example of a mitigation or management strategy used at Whitelee Windfarm or similar sites to reduce environmental impact during construction or operation.

(Total for Question 9 is 1 mark)

---

10 State TWO benefits the visitor centre at Whitelee can bring to the local area beyond energy production.

(Total for Question 10 is 1 mark)

---

11 Explain ONE limitation of relying on a single large windfarm, such as Whitelee, to meet a region's energy needs.

(Total for Question 11 is 2 marks)

---

12 Give TWO household measures that reduce energy demand and thereby help achieve sustainable energy use, with one brief reason for each measure.

(Total for Question 12 is 2 marks)

---

13 State ONE reason why locating Whitelee on former forestry and moorland was chosen rather than in an urban area.

(Total for Question 13 is 1 mark)

---

14 Suggest ONE economic disadvantage to local land users from the creation of a large windfarm on previously used moorland or forestry.

(Total for Question 14 is 1 mark)

15 Use named facts and figures about Whitelee Windfarm and your knowledge of sustainable energy use to answer this question.

Assess how successful Whitelee Windfarm has been in providing sustainable energy for Scotland and the UK.

Assess how successful Whitelee Windfarm has been in providing sustainable energy for Scotland and the UK.

(Total for Question 15 is 9 marks)

Mark scheme · GEO.KS38 Energy Security Case Study: Whitelee Windfarm and Sustainable Energy Use

Question 1

- **B1** nearest major city: Glasgow, oe
- **B1** region: on Eaglesham Moor / South Lanarkshire / near Glasgow in west central Scotland, oe
- **Answer: Near Glasgow on Eaglesham Moor in South Lanarkshire, west central Scotland.**

Question 2

- **B1** installed capacity: 539 MW
- **B1** explanation: the maximum electrical power the windfarm can produce at any instant when all turbines are generating at full output, oe
- **Answer: Installed capacity 539 MW. This is the maximum electrical power the windfarm can produce at one time when all turbines are operating at full output.**

Question 3

- **B1** creates jobs, e.g. maintenance, operations, visitor centre staff, or construction jobs during building, oe
- **Answer: It creates jobs, for example in turbine maintenance and operations, visitor centre staff and construction roles during installation.**

Question 4

- **B1** visual impact on landscape / intrusion into moorland views, or habitat disruption during construction, or noise concerns, oe
- **Answer: Visual impact on the moorland landscape, and possible habitat disruption during construction.**

Question 5

- (a) **B1** highest: 2021; lowest: 2020
- **(a) Answer: Highest: 2021. Lowest: 2020.**
- (b) **M1** 1180 - 920 seen, oe
- (b) **A1** 260 GWh cao
- **(b) Answer: 260 GWh.**
- (c) **B1** generation fluctuates year to year with no steady trend, with a low in 2020 and peaks in 2019 and 2021, oe
- **(c) Answer: Annual generation fluctuates: it falls to a low in 2020, rises to peaks in 2019 and especially 2021, and remains high in 2022 but below 2021.**

Question 6

- **M1** work shown: 1,100,000 MWh / (539 x 8760) or equivalent, oe
- **A1** 23.3% cao
- **Answer: 23.3%.**

Question 7

- **B1** reduces carbon emissions by generating low-carbon electricity, oe
- **Answer: It generates low-carbon electricity, reducing carbon emissions from the power sector.**

Question 8

- **B1** reason: wind speed varies so turbines do not produce electricity continuously, oe
- **Answer: Because wind speeds vary, turbines do not produce electricity continuously; this intermittency means output can drop when wind is low, so other generation or storage is needed to maintain reliability.**

Question 9

- **B1** example: habitat restoration, careful routing of access tracks, timing construction to avoid breeding seasons, or planting new woodland, oe
- **Answer: For example, restoring habitats and timing construction work to avoid breeding seasons to reduce wildlife disturbance.**

Question 10

- **B1** benefit 1: tourism income / increased visitors, oe
- **Answer: Tourism income and educational visits that raise public awareness of renewable energy.**

Question 11

- **B1** limitation stated, e.g. intermittency meaning output is variable and cannot be relied on at all times, oe
- **B1** linked consequence, e.g. requires backup generation or storage, increasing overall system cost or complexity, oe
- **Answer: A limitation is intermittency, because output varies with wind so the region still needs backup generation or storage which increases cost and complexity.**

Question 12

- **B1** measure 1 with reason, e.g. loft insulation to reduce heat loss and lower heating demand, oe
- **B1** measure 2 with reason, e.g. installing LED lighting to reduce electricity use per lumen, oe
- **Answer: Loft insulation to reduce heat loss and lower heating demand; LED lighting to reduce electricity use for lighting.**

Question 13

- **B1** reason: large open area with stronger and more consistent winds, available space for turbines and lower conflict with dense population, oe
- **Answer: Because moorland provides large open space with stronger, more consistent winds and fewer conflicts with dense population than urban areas.**

Question 14

- **B1** example: loss of grazing land or forestry income, or disruption to existing local businesses during construction, oe
- **Answer: Loss of grazing land or forestry income for local land users, reducing their income during and after construction.**

Question 15

- **Level 1** (1-3): Simple statements about Whitelee with limited development. May list advantages and disadvantages with little linkage or few named facts. A partial, unsupported judgement may be present.
- **Level 2** (4-6): Clear assessment using specific points about Whitelee, including some named facts or figures (for example installed capacity 539 MW, annual generation figures); considers both benefits and limitations and gives a supported judgement.
- **Level 3** (7-9): A detailed, balanced assessment that uses accurate named facts and figures about Whitelee and links these to wider sustainable energy themes. Weighs renewable low-carbon generation, jobs and visitor benefits against intermittency, visual and habitat impacts, and the need for storage or backup. Reaches a well-justified conclusion on the extent of success, recognising trade-offs and wider system implications.
- **Indicative content:**
  - Successes: Whitelee is the largest onshore windfarm in the UK with installed capacity 539 MW, producing substantial annual generation (example years 2018-2022 between about 920 and 1,180 GWh), contributing low-carbon electricity and helping reduce fossil fuel use and carbon emissions for Scotland and the UK.
  - Successes: creates local jobs in operation and maintenance and supports a visitor centre that brings tourism income and education about renewables.
  - Limitations: wind is intermittent so reliability requires backup generation or energy storage; capacity factor (example 2022) around 23.3% shows it does not operate at full capacity continuously.
  - Limitations: local environmental concerns include visual impact on Eaglesham Moor, potential habitat disruption during construction, and possible noise concerns for nearby residents.
  - Wider sustainability context: Whitelee contributes to national renewable targets and energy security by diversifying supply, but on its own cannot meet demand, so integration with other renewables, storage, demand reduction and grid upgrades is necessary.
  - Evaluation: a balanced judgement might conclude Whitelee has been largely successful as a large-scale renewable generator that contributes materially to sustainable energy, while also acknowledging the need for complementary measures to manage intermittency and local environmental impacts; a supported conclusion should state the extent of success and recommend how benefits might be increased or disadvantages reduced.